

# What Can We Learn From Plants?

# What Problems Do We Need To Solve?

# Excessive Protein Degradation During Ensiling

Most forages have extensive protein degradation during ensiling.



# Protein Degradation During Ensiling

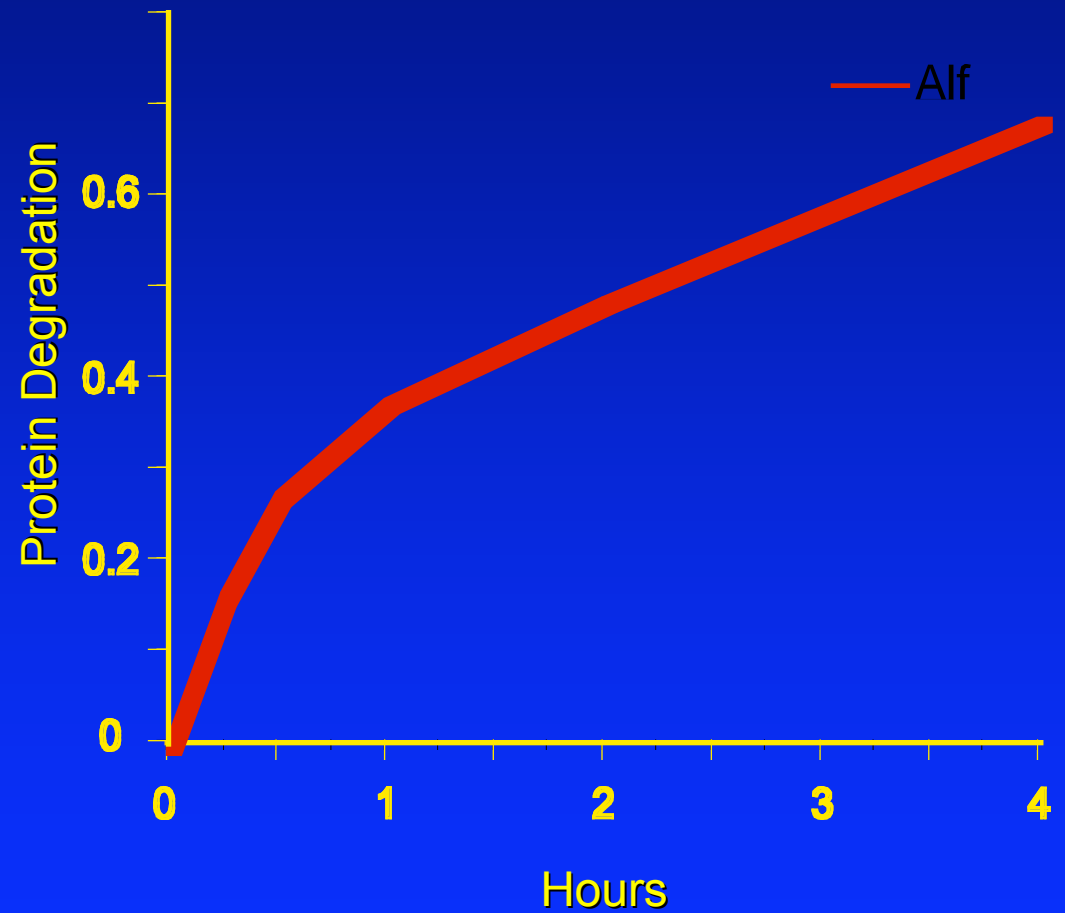
Usually rapid

Can be extensive

Alfalfa 50-75%

Grasses higher

# Alfalfa



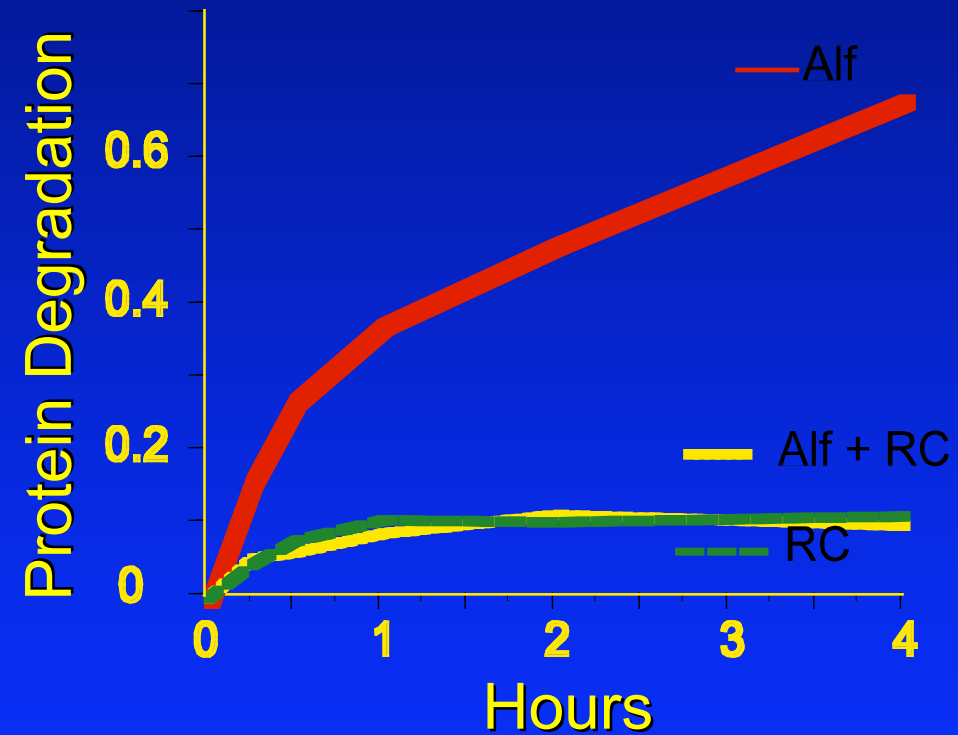
# Why is proteolysis a problem?

Proteolysis during ensiling results in losses of up to \$70 per ha for alfalfa  
\$23 per ha for corn silage

Net losses can be as high as **\$94.4 million** per year

Large negative environmental impact

# Red Clover





# Alfalfa vs. Red Clover



High in protein

Both have  
reasonably  
good  
digestibility





# Red Clover Disadvantages



Poor field stand  
persistence

Lower yields

Slow drying rates

# Red Clover Advantages



Makes a better tea

May have a role as a nutraceutical

80-90% less protein degradation

So Why Is Red Clover Protein  
Less Degraded During  
Ensiling???

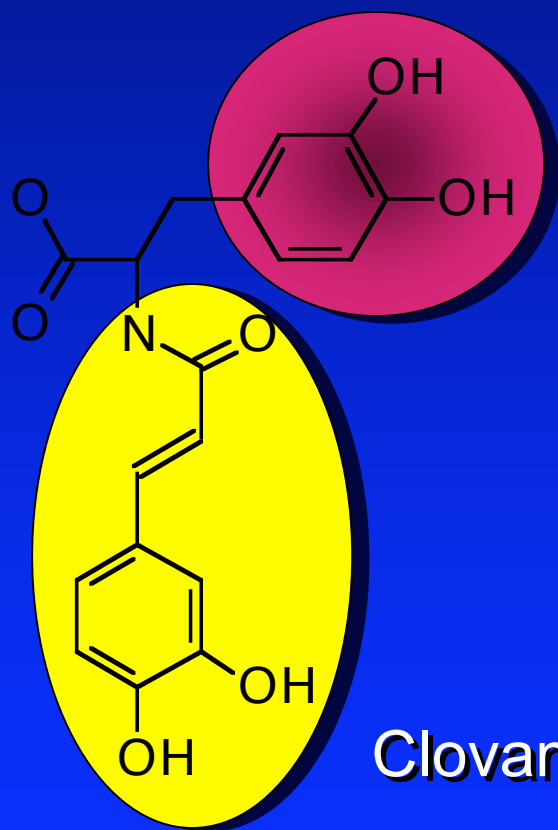
# Polyphenoloxidase

## Plant Extracts

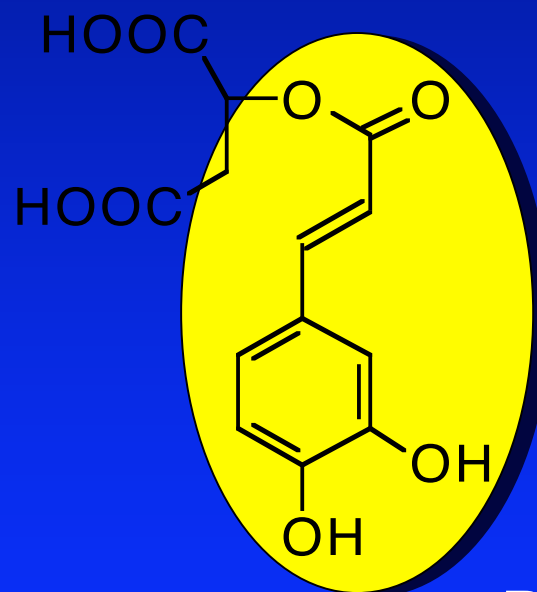
Polyphenoloxidase is an enzyme that results in the browning of fruits and vegetables.



# Red Clover PPO Substrates

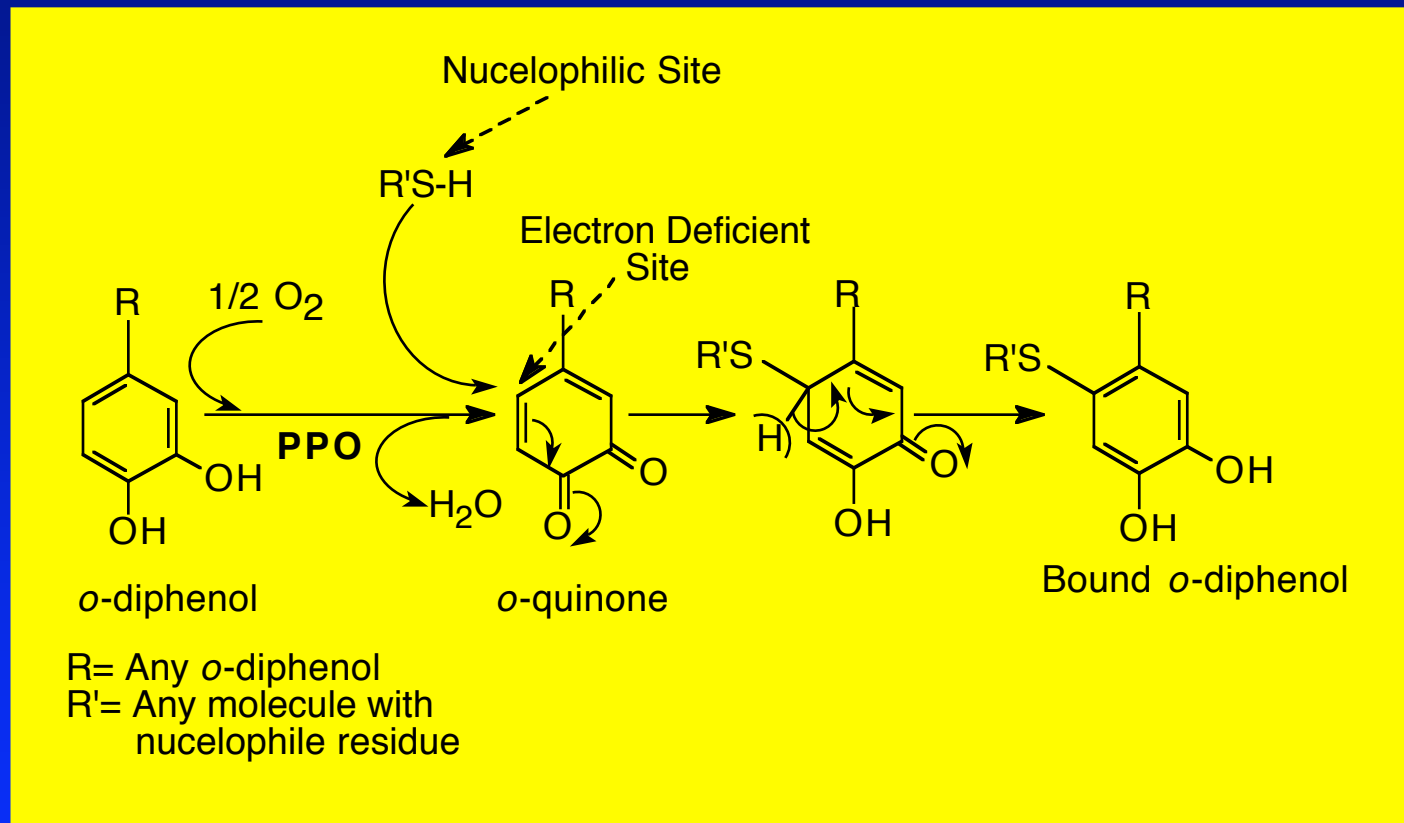


Clovamide

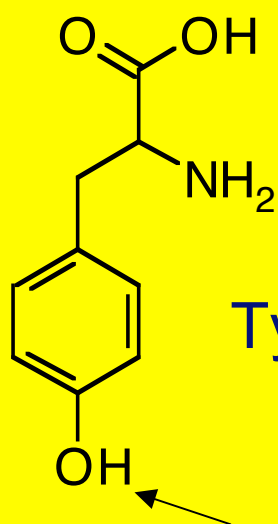


Phasic Acid

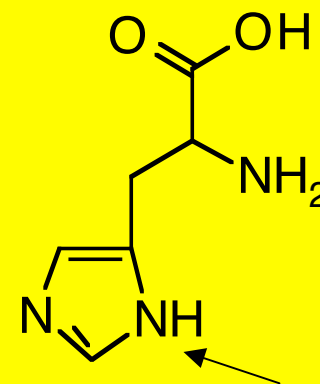
# Reaction Mechanism for PPO



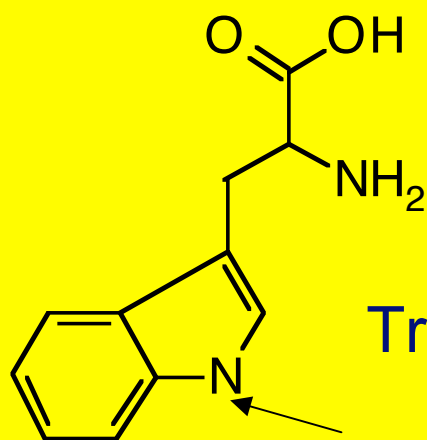
# Amino Acids With Nucelophilic Sites



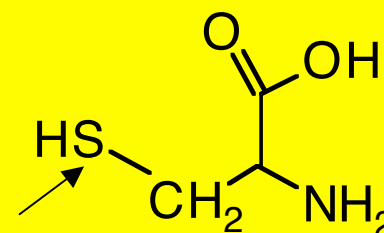
Tyrosine



Histidine



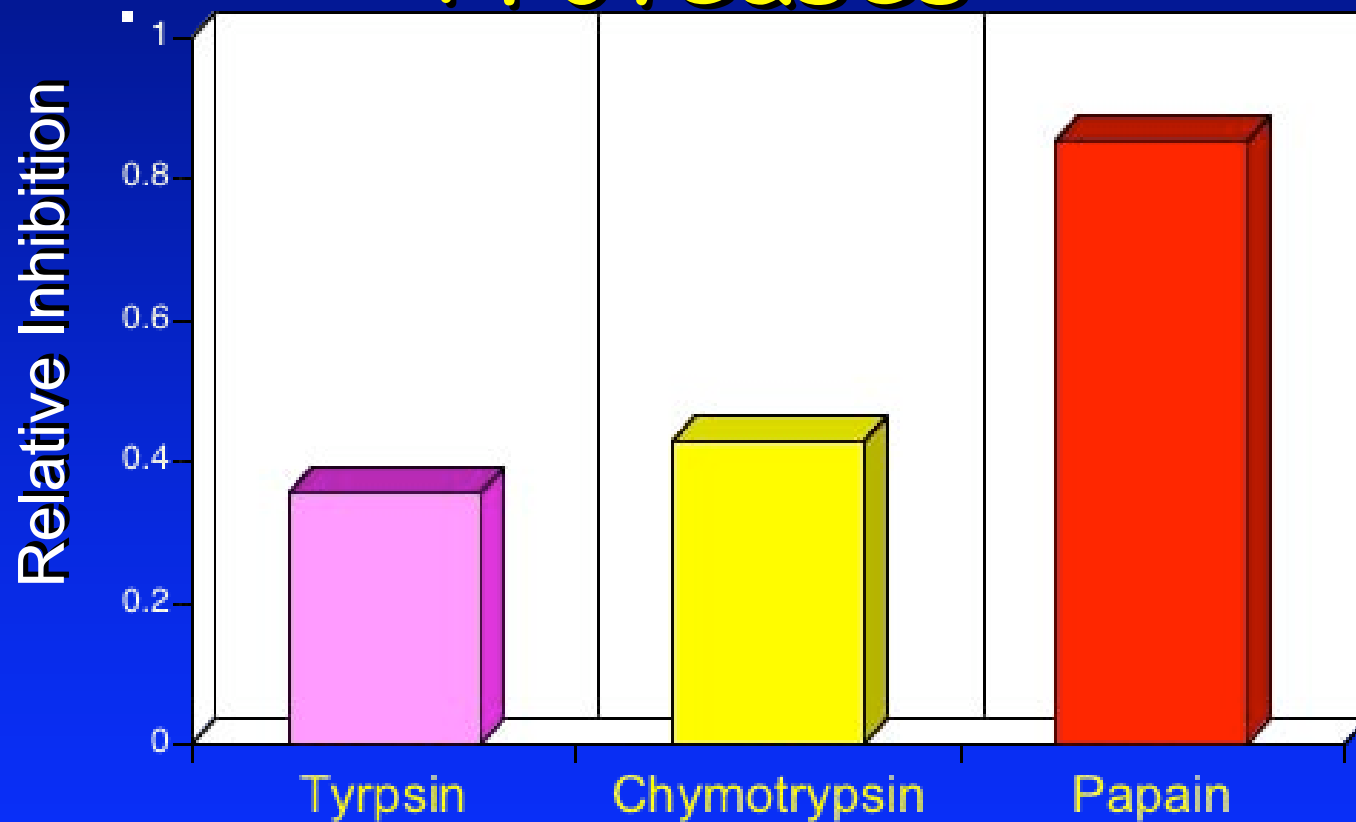
Tryptophan



Cysteine



# Impact of Red Clover Extract on Proteases



# Red Clover System

Reduced proteolytic activity appears to be due to polyphenol oxidase (PPO)

Formation of o-quinones and reaction with proteins

# What Does Red Clover Tell Us?

Duplicating the red clover system in alfalfa

Decrease protein degradation

Decrease environmental release of N

Have economic benefits

# Current Research Efforts

Insert red clover PPO gene into alfalfa

Test the impact upon the ensiling process

Develop methods of adding PPO  
substrates



# Alfalfa Advantages



Good field persistence

Good biomass yield

# Alfalfa Disadvantages

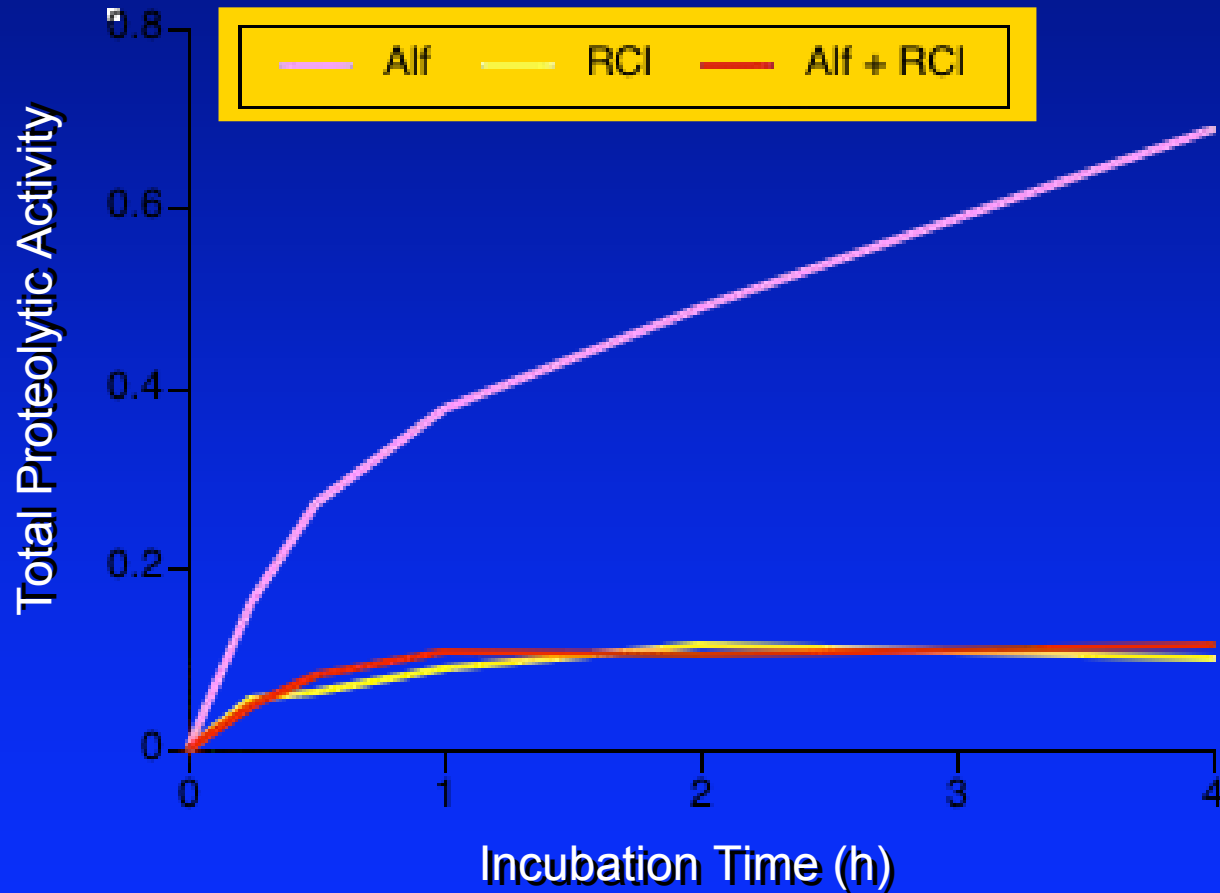


High protein losses  
during ensiling

Digestibility could  
be better



# Comparison of Alfalfa and Red Clover Proteolytic Activity



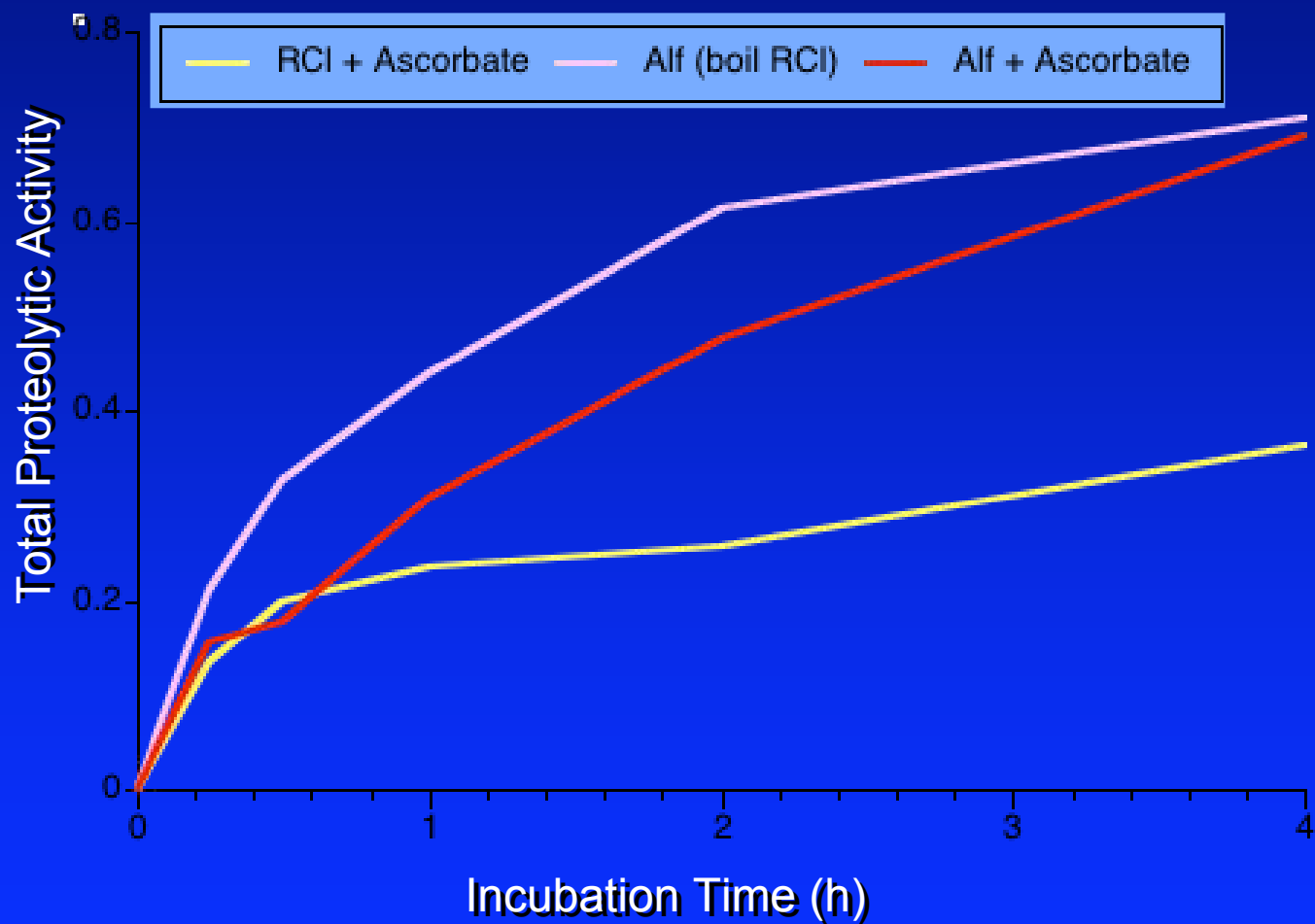
# Understanding Red Clover Silage



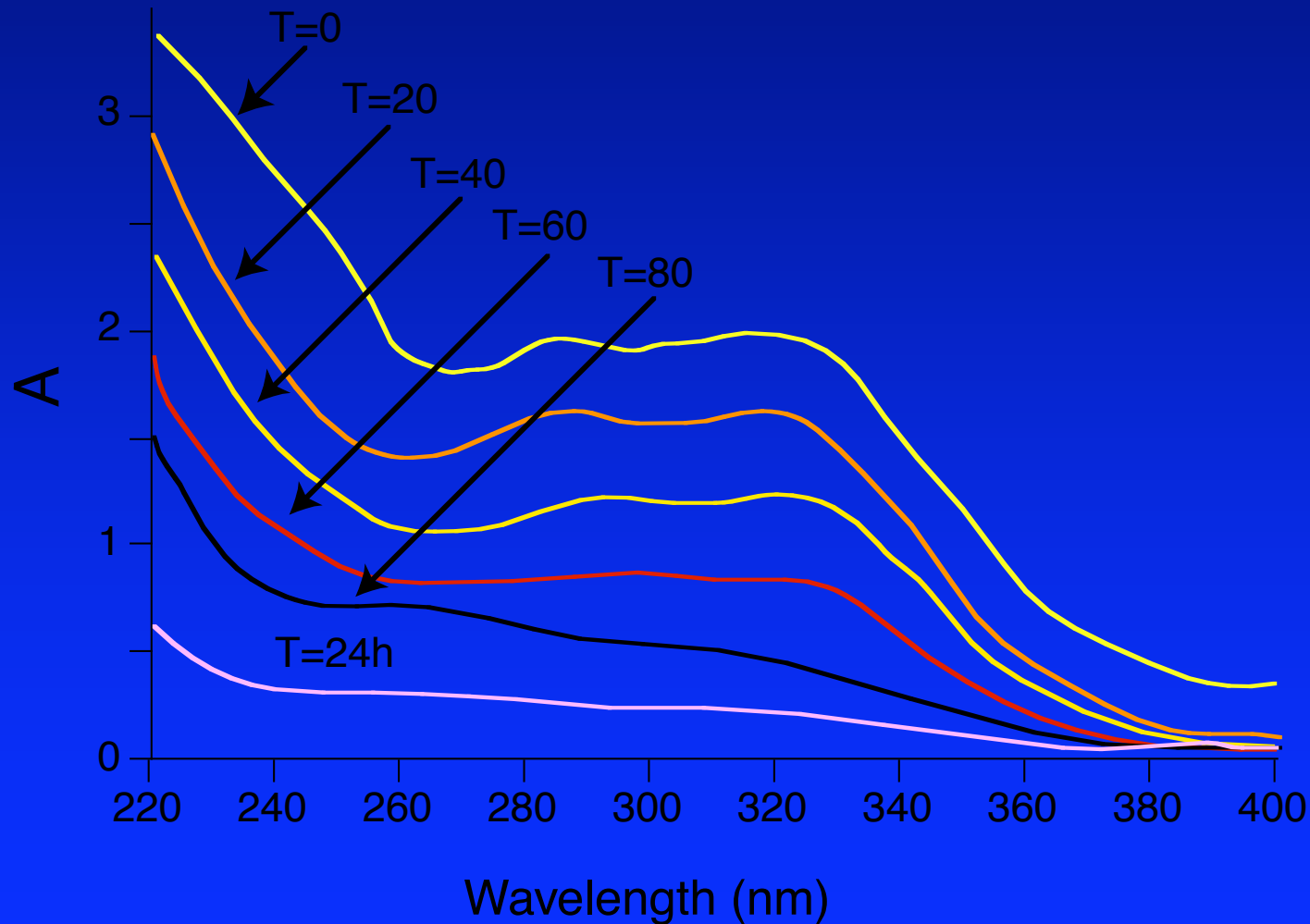
Why does  
red clover  
make a  
better silage  
than alfalfa?



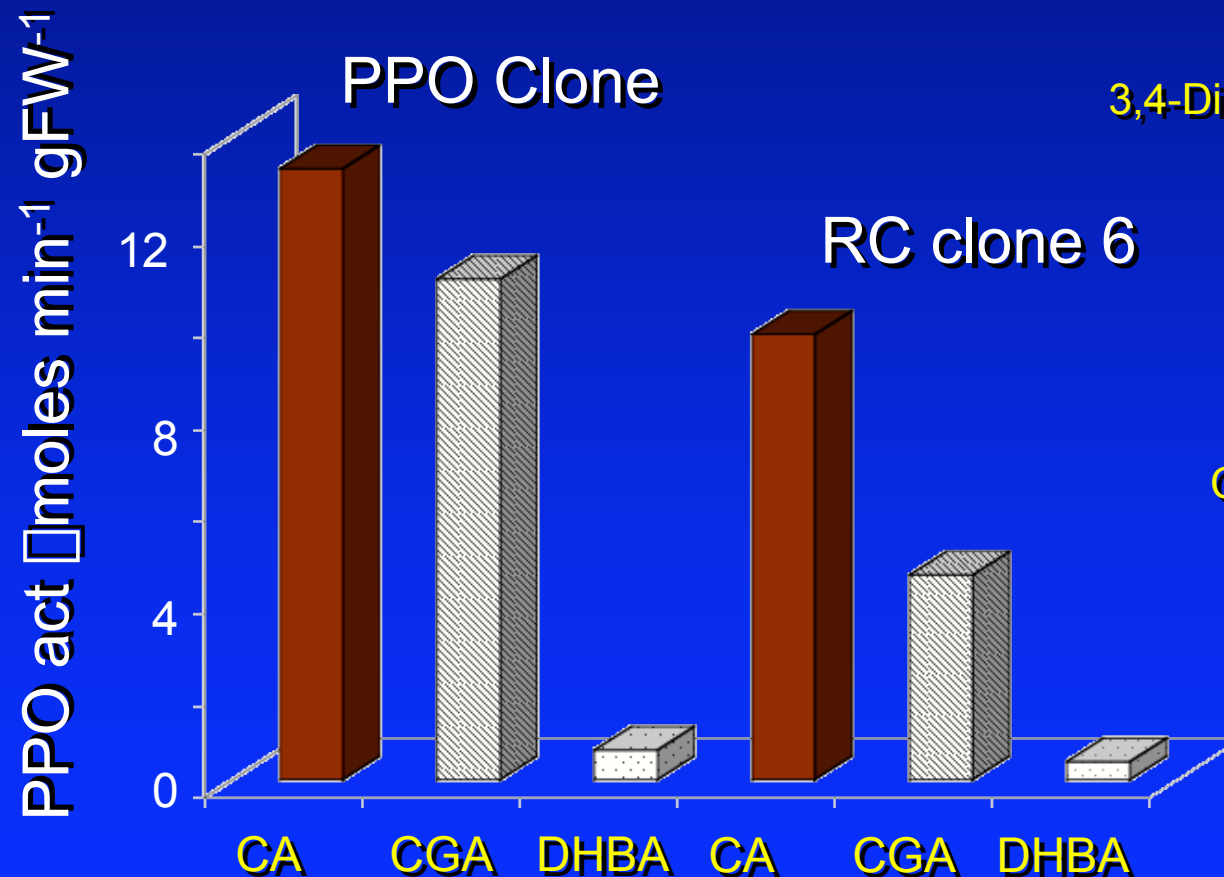
# What's in Red Clover?



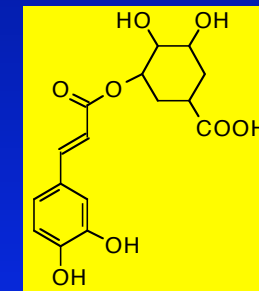
# Changes in Spectral Characteristics



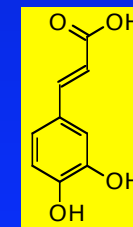
# Comparison of PPO Activity in Different Red Clover Clones



3,4-Dihydroxybenzoic acid (DHBA)



Chlorogenic Acid (CGA)



Caffeic Acid (CA)

# Changes in PPO Substrates

